

CUSTOMER NO. 46850

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Re: Attorney Docket No. Greywall 34

In re application of: Dennis S. Greywall

Serial No.: 10/789,074

Group Art Unit: 1791

Filed: 02/27/2004

Examiner: Lazorcik, Jason L.

Matter No.: 990.0626

Phone No.: 571-272-2217

For: Carbon Particle Fiber Assembly Technique

APPELLANT'S BRIEF (37 CFR 41.37)

Mail Stop Appeal Brief - Patents

Commissioner for Patents

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ATTENTION: Board of Patent Appeals and Interferences

In response to the Final Office Action of 10/29/07, and further to the Advisory Action dated 12/26/07 and the Notice of Panel Decision from Pre-Appeal Brief Review dated 02/01/08, the Applicant (now Appellant) submits this Appellant's Brief in support of the appeal.

REAL PARTY IN INTEREST (37 CFR 41.37(c)(1)(i))

Other than the named inventors listed in the caption of this brief, the real party in interest is the assignee Lucent Technologies Inc. of Murray Hill, New Jersey.

RELATED APPEALS AND INTERFERENCES (37 CFR 41.37(c)(1)(ii))

None.

STATUS OF CLAIMS (37 CFR 41.37(c)(1)(iii))

Claims 1-22, 26-28, and 40-49 are rejected. Claims 1-22, 26-28, and 40-49 are being appealed.

STATUS OF AMENDMENTS (37 CFR 41.37(c)(1)(iv))

All previously filed amendments have been entered.

SUMMARY OF CLAIMED SUBJECT MATTER (37 CFR 41.37(c)(1)(v))

In accordance with the principles of the invention, carbon particles, such as carbon fibrils and/or carbon nanotube molecules, are assembled into aligned fibers using processes derived from the processes used to manufacture optical fiber. More particularly, the carbon particles are embedded in glass, which is then drawn to align them. By aligned it is meant that the axis along the longest dimension of each of the various particles in a local vicinity are substantially parallel. An initial mixture may be formed by dispersing the carbon particles within a sol-gel solution. An ester is added to the mixture, causing it to solidify into a body, which may be porous. At this point, the body may optionally be imbued with one or more other materials to influence the properties of the body so as to benefit the processing or the characteristics of the final fiber. The body may then be heated to consolidate it, i.e., to remove some or all of the pores, if any, thereby forming a consolidated body. The heating may be performed in the presence of a gas, e.g., to keep oxygen away from the consolidated body. The consolidated body is then drawn into a fiber. (See, e.g., page 1, lines 17-32.)

The drawing into a fiber may be achieved by inserting the consolidated body within a larger glass body with a hole in it, e.g., a piece of glass tubing, that can receive the consolidated body. In accordance with one aspect of the invention, multiple consolidated bodies may be placed within the

larger glass body, provided that the larger glass body has multiple holes, at least one for each consolidated body. The larger glass body including the at least one consolidated body is then further consolidated, e.g., heated, so that the consolidated bodies are merged with the larger glass body into a single so called “preform.” (See, e.g., page 2, lines 1-8.)

The preform is then drawn, using conventional optical fiber techniques, into a glass fiber that has at least one carbon fiber within it, e.g., one for each consolidated body that was placed within the larger glass body. As the glass fiber is drawn, the carbon particles from each consolidated body respectively align themselves and bond together to form a respective carbon fiber within the glass fiber. Optionally, the drawn glass fiber containing the carbon fiber(s) may be twisted, and reheated if necessary to facilitate the twisting, thereby causing the carbon fiber(s) to be drawn toward the axis of the glass fiber and thereby expel some of the glass between and within the carbon fiber(s). Lastly, optionally, some or all of the glass coating the carbon fibers may be removed, e.g., using chemical or mechanical processes, or a combination thereof. (See, e.g., page 2, lines 9-20.)

Independent claim 1 is directed to a method for assembling carbon particles into at least one aligned carbon fiber. The method has the step of drawing glass containing said carbon particles so as to form at least one carbon fiber from said carbon particles. Support for claim 1 can be found in Appellants’ specification, e.g., in Figs. 4-5 and on page 5, lines 8-23.

Claim 45, which depends from claim 1, further specifies that the method has the steps of: (A) dispersing said carbon particles within a form of liquid glass to form a sol-gel solution; and (B) solidifying the sol-gel solution to form a glass body containing therein said carbon particles. The step of drawing recited in claim 1 comprises: (C) drawing said glass body into the at least one carbon fiber. Support for claim 45 can be found in Appellants’ specification, e.g., in Figs. 1-2 and on page 1, lines 23-32.

Claims 8-10, which depend variously from claim 1, further specify that the method has the step of forming said glass containing carbon particles, wherein said forming step includes the steps of: (i) solidifying a mixture of carbon particles within a sol-gel solution whereby a body is formed, and (ii) dispersing carbon particles within said sol-gel solution to form said mixture. Support for claims 8-10 can be found in Appellants’ specification, e.g., in Figs. 1-2 and on page 1, lines 23-32.

Independent claim 26 is directed to a method for assembling carbon particles into at least one aligned carbon fiber. The method has the step of drawing a preform of glass containing carbon particles so as to form said carbon fiber, whereby said carbon particles are substantially aligned.

Support for claim 26 can be found in Appellants' specification, e.g., in Figs. 4-5 and on page 5, lines 8-23.

Claim 47, which depends from claim 26, further specifies that the method has the steps of: (A) dispersing carbon particles within a form of liquid glass to form a sol-gel solution; (B) solidifying the sol-gel solution to form a glass body containing therein said carbon particles; and (C) incorporating said glass body into a larger glass structure to form a preform, wherein the step of drawing comprises drawing the preform into said carbon fiber. Support for claim 47 can be found in Appellants' specification, e.g., in Figs. 1-2 and on page 1, lines 23-32.

Independent claim 40 is directed to a method for producing at least one carbon fiber. The method has the step of embedding carbon particles in glass. The method further has the step of drawing said glass with said embedded carbon particles into a carbon fiber so that said carbon particles are substantially aligned within said carbon fiber. Support for claim 40 can be found in Appellants' specification, e.g., in Figs. 4-5 and on page 5, lines 8-23.

Claim 42, which depends from claim 40, further specifies that the embedding step includes the steps of: (A) dispersing carbon particles within a form of liquid glass to form a sol-gel solution; and (B) solidifying the sol-gel solution to form said glass with said embedded carbon particles. Support for claim 42 can be found in Appellants' specification, e.g., in Figs. 1-2 and on page 1, lines 23-32.

GROUND OF REJECTION TO BE REVIEWED ON APPEAL (37 CFR 41.37(c)(1)(vi))

A first issue is whether claims 1, 3, 6, 8-10, 19-21, 26, 28, 40, 42, 45, and 47 are anticipated under 35 U.S.C. § 102(b) by Roeder (DE 3,516,920).

A second issue is whether claims 12-18, 43, 46, and 48 are anticipated under 35 U.S.C. § 102(b) by Roeder or, in the alternative, are unpatentable under 35 U.S.C. 103(a) over Roeder.

A third issue is whether claims 4, 5, 7, 44, and 49 are unpatentable under 35 U.S.C. § 103(a) over Roeder in view of Hearle (as presented by Zhang, Science, 2004, v. 306, pp. 1358-1361).

A fourth issue is whether claim 22 is unpatentable under 35 U.S.C. § 103(a) over Roeder.

A fifth issue is whether claim 11 is unpatentable under 35 U.S.C. § 103(a) over Roeder in view of Chandross (US 5,240,488).

A sixth issue is whether claims 2, 27, and 41 are unpatentable under 35 U.S.C. § 103(a) over Roeder in view of Kumar (Macromolecules, 2002, v.35, pp. 9039-9043).

Roeder, Hearle, Zhang, Chandross, and Kumar are referred to herein collectively as “the cited references.”

ARGUMENT (37 CFR 41.37(c)(1)(vii))

Rejections under 35 U.S.C. §§ 102(b) and 103(a) over Roeder and/or combinations of references having Roeder

Claims 1-22, 26-28, and 40-49:

The method defined in claim 1 has the step of “drawing glass ... so as to form at least one carbon fiber from ... carbon particles.” By contrast, the method disclosed by Roeder is based on embedding previously formed fiber bundles into a glass matrix. Therefore, it is submitted that the method disclosed by Roeder cannot serve as an example of the method defined in claim 1 at least because there is no formation of carbon fibers from carbon particles in the method of Roeder.

More specifically, the method disclosed by Roeder is directed to the production of a composite material that has improved mechanical characteristics compared to those of unreinforced glass. According to that method, a prefabricated (carbon or silicon-carbide) fiber bundle is impregnated with glass powder and placed into a hollow mandrel. The tip of the hollow mandrel has a cone-shaped taper with a hole connecting the mandrel to a glass-melt volume. The glass melt is extruded from the volume through a die channel. The glass-impregnated fiber bundle is drawn through the hole in the mandrel into the glass-melt volume and is pushed together with the glass melt through the die channel to form a glass rod or profile having a fiber-reinforced core. (See Roeder’s pages 11-13.)

The prefabricated fibers used in the method of Roeder are relatively long fibers spooled on cardboard rolls. At about 600°C, the sizing that covers the spooled fibers is stripped off and the individual filaments of each fiber are loosened from one another. The fibers thus treated are cut to a suitable length and a relatively large number of the resulting fiber pieces are bundled together to form, after the glass impregnation, the prefabricated fiber bundle, which is then placed into the hollow mandrel. (See Roeder’s pages 22-23.)

To impregnate a fiber bundle with glass powder, the fiber bundle is immersed, for approximately 45 seconds, into a suspension of boiling alcohol and glass powder. The boiling of the alcohol swirls and agitates the glass powder to uniformly distribute the glass powder in the liquid. When the fiber bundle is immersed into this boiling suspension, the glass powder infiltrates

the fiber bundle. After the fiber bundle is removed from the boiling suspension and the alcohol is evaporated, the glass powder that has infiltrated the fiber bundle adheres to the individual fiber filaments, thereby forming the glass-impregnated fiber bundle. (See Roeder's pages 15 and 23.)

Based on the above characterization of Roeder, the Appellant submits that the method of Roeder differs from the method of claim 1 in at least that, in the former method, glass is drawn to embed into it the already existing, previously formed carbon fiber obtained from an external source (e.g., a cardboard spool), whereas in the latter method, glass is drawn to form a carbon fiber from carbon particles contained in the glass, with the carbon fiber being newly formed as the glass is being drawn.

On pages 11-12 of the final office action the Examiner asserts that Roeder's step of compacting the previously loosened filaments of prefabricated fibers in the process of drawing them through the cone-shaped taper of the hollow mandrel is an example of the step of "drawing glass containing said carbon particles so as to form at least one carbon fiber from said carbon particles" recited in claim 1. For the following reasons, the Appellant respectfully disagrees.

First, the Appellant submits that no fiber is being formed from carbon particles in the method of Roeder because, even after the filaments have been loosened, the previously formed carbon fiber does not cease to exist. Although the filaments of a fiber bundle are loosened from each other, neither the individual filaments nor the fibers in the bundle are reverted back to mere particles. Instead, they remain fibers. The fact that the degree of fiber disintegration due to the filament loosening is very slight is made very clear, for example, by the following passages in Roeder. The fibers composed of loosened filaments can still be cut to a suitable length and combined into bundles (see Roeder's page 23). The glass powder used in the impregnation process has a very fine grain size (less than about 40 μm) and, yet, there is substantially no loss of this glass powder from the impregnated fiber bundle as it is being moved into the hollow mandrel (see Roeder's pages 23-24). If the degree of fiber disintegration were not slight, then it would not be possible to keep the fine glass powder sufficiently entrapped between the filaments to enable the powder to survive, without being shaken off, the process of mechanically moving the glass-impregnated fiber bundles into the hollow mandrel.

Because the degree of fiber disintegration is very slight and the loosened filaments remain fibers, there is no formation of carbon fibers from carbon particles in the method of Roeder. This conclusion is reinforced by the fact that Roeder himself describes his method as one in which

the fiber is “precompacted,” “radially compressed” (page 12), and subjected to “compacting and shaping” (page 15), but never as one in which the fiber is created or formed from carbon particles. In contrast, claim 1 requires that at least one carbon fiber be formed from carbon particles.

Second, even if the “formation” of carbon fiber was present in the method of Roeder, which the Appellant does not admit, the carbon fiber would have been formed from carbon filaments, and not from carbon particles as required by claim 1. Although, on page 12 of the final office action, the Examiner contends that “carbon filaments” represent an example of “carbon particles,” the Appellant respectfully disagrees and submits that such an interpretation of these terms is improper. The reasons for this disagreement are outlined below.

At page 903, Merriam-Webster’s Collegiate Dictionary defines a particle as “a minute quantity or fragment” or “a relatively small or the smallest discrete portion or amount of something” (see the Eleventh Edition, Merriam-Webster, Inc., Springfield, Massachusetts, 2003). At page 467, the Dictionary further defines a filament as “a single thread or a thin flexible threadlike object, process, or appendage.” At page 464, the Dictionary further defines a fiber as “a thread or a structure or object resembling a thread: ... a slender and greatly elongated natural or synthetic filament (as of wool, cotton, asbestos, gold, glass, or rayon) typically capable of being spun into yarn.” Based on these definitions, it is submitted that there is a significant difference between a “particle” and a “filament.” One representative line of distinction between a “particle” and a “filament” can be drawn based on size. For example, it is clear that Roeder’s carbon filaments are relatively large objects that can be mechanically grabbed and piled into bundles. It is submitted that this fact provides a first piece of compelling evidence that Roeder’s filaments may not be appropriately construed as minute quantities or fragments. In contrast, Appellant’s specification makes it clear that “carbon particles” are relatively small objects that, for example, can be dispersed in a glass body to form a sol-gel solution (see page 4, lines 8-19). Clearly, Roeder’s filaments are too large to form a sol-gel solution and, as such, cannot serve as an example of carbon particles recited in claim 1. This fact provides a second piece of compelling evidence that Roeder’s filaments may not be appropriately construed as minute quantities or fragments.

For at least these reasons, the Appellant submits that the Examiner misinterpreted the teachings of Roeder and used them improperly to reject claim 1. It is therefore submitted that claim 1 is allowable over Roeder and its rejection over Roeder should be withdrawn. For similar reasons, it is submitted that claims 26 and 40 are allowable over Roeder. Since the rest of the claims depend

variously from claims 1, 26, and 40, it is further submitted that those claims are allowable over Roeder and the cited reference combinations that include Roeder. The Appellant submits therefore that the rejections of claims under §§ 102 and 103 over the cited references have been overcome.

Claims 10, 42, 45, and 47:

Claim 45 recites the step of dispersing carbon particles within a form of liquid glass to form a sol-gel solution. Claim 45 further recites the step of solidifying the sol-gel solution to form a glass body containing therein said carbon particles. In the method of Roeder, glass particles, not carbon particles, are being dispersed in alcohol and then two solids are aggregated to form a composite material. It is submitted that the method disclosed by Roeder cannot serve as an example of the method defined in claim 45 at least because (1) Roeder's fibers in the fiber bundle remain structurally intact and are not being dispersed in any manner at all and (2) there is no sol-gel-solution solidification in the method disclosed by Roeder. Differences between the method defined in claim 45 and the method disclosed by Roeder are further detailed below.

In the rejection of claim 45, on page 5 of the final office action, in reference to Roeder, the Examiner stated that:

This sol-gel impregnation process is implicitly understood to encompass Applicants claimed step of dispersing the carbon particles in a sol-gel solution (claim 42, 45) and "solidifying" at least a portion of the sol-gel solution to "form a glass body containing therein said carbon particles."

In response, the Appellant submits that this characterization of Roeder is unfounded and improper.

The term "dispersing" means distributing more or less evenly throughout a medium (see, for example, Merriam-Webster's Collegiate Dictionary, Eleventh Edition, Merriam-Webster, Inc., Springfield, Massachusetts, 2003, p. 361). In the method of Roeder, glass particles, not carbon particles, are being dispersed in alcohol, whereas the fibers of the fiber bundle remain structurally intact and are not being dispersed in any manner at all (see, e.g., Roeder's page 15, the first full paragraph).

Solidifying a substance means making that substance solid or hard (see, for example, Merriam-Webster's Collegiate Dictionary, Eleventh Edition, Merriam-Webster, Inc., Springfield, Massachusetts, 2003, p. 1187). In the method of Roeder, the already solid glass particles of the glass/alcohol suspension adhere to the already solid fiber bundle (see, e.g., Roeder's page 15, the

first full paragraph). Thus, in the method of Roeder, one solid is simply aggregated with another solid. When the two aggregated solids are heated up and drawn through the hole in the mandrel there is no sol-gel solution at that point at least because the solvent has already been removed. Although it is true that the heat melts the solid glass particles in the bundle, this melting does not create a sol-gel solution that can be subsequently solidified to form a glass body to be drawn as required by claim 45.

All these facts provide additional reasons for the allowability of claim 45 over the cited references. At least some of these reasons similarly apply to the allowability of claims 42 and 47 over the cited references.

With respect to claim 10, the Appellant specifically notes that the Examiner's rejection of that claim is improper and should be withdrawn. In particular, claim 10 and its base claims recite the steps of (a) solidifying a mixture of carbon particles within a sol-gel solution whereby a body is formed and (b) dispersing carbon particles within said sol-gel solution to form said mixture. For at least some of the reasons already explained above in reference to claim 45, the Applicant submits that Roeder does not teach or even suggest such steps. It therefore follows that the Examiner misinterpreted the teachings of Roeder and used them improperly to reject claim 10.

CLAIMS APPENDIX (37 CFR 41.37(c)(1)(viii))

1 1. (Previously presented) A method for assembling carbon particles into at least one
2 aligned carbon fiber, the method comprising the step of drawing glass containing said carbon
3 particles so as to form at least one carbon fiber from said carbon particles.

1 2. (Original) The invention as defined in claim 1 wherein said carbon particles are
2 carbon nanotube molecules.

1 3. (Original) The invention as defined in claim 1 wherein said carbon particles are
2 carbon fibrils.

1 4. (Original) The invention as defined in claim 1 further comprising the step of twisting
2 said fiber.

1 5. (Original) The invention as defined in claim 1 further comprising the step of twisting
2 said fiber while heating said fiber to facilitate its twisting.

1 6. (Original) The invention as defined in claim 1 further comprising the step of heating
2 said glass containing carbon particles while drawing it.

1 7. (Previously presented) The invention as defined in claim 46, wherein said expelling
2 step comprises twisting said plurality of aligned carbon fibers, whereby said aligned carbon fibers
3 are drawn towards the axis of said fiber.

1 8. (Original) The invention as defined in claim 1 further comprising the step of forming
2 said glass containing carbon particles.

1 9. (Original) The invention as defined in claim 8 wherein said forming step further
2 comprises the step of solidifying a mixture of carbon particles within a sol-gel solution whereby a
3 body is formed.

1 10. (Original) The invention as defined in claim 9 wherein said forming step further
2 comprises the step of dispersing carbon particles within said sol-gel solution to form said mixture.

1 11. (Previously presented) The invention as defined in claim 45, wherein said solidifying
2 step comprises adding an ester to said sol-gel solution.

1 12. (Previously presented) The invention as defined in claim 45, wherein said body is
2 porous.

1 13. (Previously presented) The invention as defined in claim 45, further comprising the
2 step of imbuing said body with at least one other material.

1 14. (Previously presented) The invention as defined in claim 45, further comprising the
2 step of heating said glass body to consolidate it, whereby a consolidated body is formed.

1 15. (Previously presented) The invention as defined in claim 45, further comprising the
2 step of incorporating said glass body into a larger structure to form a preform.

1 16. (Previously presented) The invention as defined in claim 15, wherein said larger
2 structure is a glass structure having a hole that is sized to receive said glass body.

1 17. (Previously presented) The invention as defined in claim 15, further comprising the
2 step of heating said preform to consolidate it.

1 18. (Previously presented) The invention as defined in claim 15 further comprising the
2 step of incorporating at least one other body into said larger body so that said preform contains
3 multiple bodies.

1 19. (Previously presented) The invention as defined in claim 1 further comprising the
2 step of removing some glass from said carbon fiber.

1 20. (Previously presented) The invention as defined in claim 19 wherein said glass that
2 is removed is from an exterior portion of said carbon fiber.

1 21. (Original) The invention as defined in claim 19 wherein said removing is performed
2 using at least a mechanical process.

1 22. (Original) The invention as defined in claim 19 wherein said removing is performed
2 using at least a chemical process.

23-25. (Canceled)

1 26. (Previously presented) A method for assembling carbon particles into at least one
2 aligned carbon fiber, the method comprising the step of drawing a preform of glass containing
3 carbon particles so as to form said carbon fiber, whereby said carbon particles are substantially
4 aligned.

1 27. (Original) The invention as defined in claim 26 wherein said carbon particles are
2 carbon nanotube molecules.

1 28. (Original) The invention as defined in claim 26 wherein said carbon particles are
2 carbon fibrils.

29-39. (Canceled)

1 40. (Previously presented) A method for producing at least one carbon fiber, the method
2 comprising the steps of:

3 embedding carbon particles in glass; and

4 drawing said glass with said embedded carbon particles into a carbon fiber so that said
5 carbon particles are substantially aligned within said carbon fiber.

1 41. (Original) The invention as defined in claim 40 wherein said carbon particles are
2 carbon nanotube molecules.

1 42. (Previously presented) The invention as defined in claim 40, wherein said embedding
2 step comprises:

3 dispersing carbon particles within a form of liquid glass to form a sol-gel solution;
4 solidifying the sol-gel solution to form said glass with said embedded carbon
5 particles.

1 43. (Previously presented) The invention as defined in claim 42, wherein said drawing
2 step produces a plurality of aligned carbon fibers, the method further comprising the step of
3 expelling glass that is located between and within said aligned carbon fibers.

1 44. (Previously presented) The invention as defined in claim 43, wherein said expelling
2 step comprises twisting said plurality of aligned carbon fibers, whereby said aligned carbon fibers
3 are drawn towards the axis of said fiber.

1 45. (Previously presented) The invention as defined in claim 1, further comprising the
2 steps of:

3 dispersing said carbon particles within a form of liquid glass to form a sol-gel solution; and
4 solidifying the sol-gel solution to form a glass body containing therein said carbon particles,
5 wherein the step of drawing comprises:
6 drawing said glass body into the at least one carbon fiber.

1 46. (Previously presented) The invention as defined in claim 45, wherein said drawing
2 step produces a plurality of aligned carbon fibers, the method further comprising the step of
3 expelling glass that is located between and within said aligned carbon fibers.

1 47. (Previously presented) The invention as defined in claim 26, further comprising the
2 steps of:
3 dispersing carbon particles within a form of liquid glass to form a sol-gel solution;
4 solidifying the sol-gel solution to form a glass body containing therein said carbon particles;
5 and
6 incorporating said glass body into a larger glass structure to form a preform, wherein the step
7 of drawing comprises:
8 drawing the preform into said carbon fiber.

1 48. (Previously presented) The invention as defined in claim 47, wherein said drawing
2 step produces a plurality of aligned carbon fibers, the method further comprising the step of
3 expelling glass that is located between and within said aligned carbon fibers.

1 49. (Previously presented) The invention as defined in claim 48, wherein said expelling
2 step comprises twisting said plurality of aligned carbon fibers, whereby said aligned carbon fibers
3 are drawn towards the axis of said fiber.

EVIDENCE APPENDIX (37 CFR 41.37(c)(1)(ix))

None.

RELATED PROCEEDINGS APPENDIX (37 CFR 41.37(c)(1)(x))

None.

Respectfully submitted,

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